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Process for Monitoring Paper Sheets

In a process for monitoring paper sheets by scanning the sheet with radiation along a preset scanning stretch and by generating a sequence of scanning signals determined by the characteristics of the paper sheet, scanning signals are generated dependent on the radiation permeability of the paper sheet. The values of the scanning signals are compared with stored set values for the purpose of emitting an identification signal. An average of the scanning signals and a corresponding average of the set values are used for comparison.

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Process for M nit ring Pap r Sh ets

The invention pertains to a process for monitoring paper sheets for multiple transport by scanning the sheets with radiation along a preset scanning stretch and by generating a sequence of scanning signals determined by the paper sheet characteristics; the signals are compared with stored set values for the purpose of emitting an identification signal.

A process of this nature is known from DE-PS 20 40 963 and is intended for testing documents such as bank notes for genuineness. To this end, the document is irradiated during scanning, and the light reflected on its surface yields a sequence of scanning signals. The signal amplitude changes in the scanning process for areas with different reflectivity. A preset amplitude course is stored as a sequence of set values for each document type to be monitored, and a comparison of the respective sequence of scanning signals and their corresponding stored sequence of set values yield information if the monitored document is genuine or not.

This process can be used when inserting bank notes in a money machine, for example. Such testing for genuineness is, however, inadequate for a comprehensive evaluation because the bank notes would also have to be counted accurately in the process. The application of the reflection principle for generating the scanning signals permits only a test of surface characteristics but not for monitoring the proper transport of one single bank note each. Multiple transport of bank notes, the so-called double runs, were detected up to now with mechanical devices, most frequently roll scanners that also perform a thickness measurement of the transported paper sheets. Such thickness measurement is prone to failure due to dirt and requires for its proper function careful adjustments and maintenance. A touchless determination of multiple transport of paper sheets especially of bank notes is not possible with the currently known monitoring procedures but it could advantageously replace the mechanical devices that are expensive in design and complex in maintenance.

It is the task of this invention to present a possibility for touchless detection of a multiple transport of paper sheets that works without mechanically moving elements and is directly incorporated in a measuring process.

The task is solved by a process

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of the nature discussed above in that the scanning signals are generated dependent in the radiation permeability of the paper sheets and that an average of scanning signals and an equivalent average of set values are used for comparison.

The invention is based on the understanding that the radiation permeability of a material decreases exponentially with its thickness. For example, if a paper she t of a given thickness has a specific dampening value decreasing th radiation intensity, an additional sheet will incr ase a total dampening effect which is

proportional to the product the individual dampening. In this manner, doubling the paper sheet thickness in a double transport of paper sheets, for example, results in a correspondingly high intensity differenc of the generated scanning signals in comparison to the normal case. This assures a very reliable distinction between the single and double transport of paper sheets.

Another advantage of generating the scanning signals with radiation permeating the paper sheets is that this principle is highly insensitive toward the changing reflexion degree of the paper sheet surface which is caused, for example, by an imprint or by dirt. Such changes of the paper sheet surface have such insignificant thickness in most cases that the radiation permeability of the paper sheet is influenced to a comparatively minor degree.

In order to assure a reliable determination of a multiple transport in the event of stronger soiling and/or greater brightness differences caused by imprints, for example, the process under the invention provides for an even average formation of the scanning signals and the set values. This results in statistically more definite comparable results.

The intensity of the radiation used for scanning a certain paper sheet type is set corresponding with the preset value range of the average. This permits that the signals to be compared are optimally aligned with the sensitivity range of the evaluation device even for different types of paper sheets.

The process according to the invention will result in a reliable statement about individual or multiple transports of paper sheets even when the transported sheets are not stacked

exactly above on another but ar shifted relative to one another. To identify large shifting ranges as multiple transports, the process can be further enhanced in that the path traversed during scanning by the paper sheets is determined and compared with a preset set value for the purpose of generating another identification signal. This permits that paper sheet stacks with a length exceeding the preset format are additionally recognized and provides another criterion for detecting multiple transports.

In general, the process under the invention has the advantage that it can also be employed in combination with the reflexion process which makes it possible to test the genuineness and to monitor the transport of individual sheets in the same device.

The invention is explained in greater detail with reference to the figure of an exemplary embodiment.

Fig. 1 shows a basic rendition on the basis of the reciprocal action of the functional units involved,

Fig. 2 shows a flow diagram of a measuring procedure used in the process for determining set values,

Fig. 3 shows a control function to detect the current to supply the radiation source, and

Fig. 4 a flow diagram of an exemplary embodiment of the invention.

Fig. 1 shows a block diagram with a monitoring device for detecting multiple transports of bank notes in a money machine. A bank note 10 to be monitored for multiple transport is fed between a controllable radiation source 12 and a radiation receiver module 20. The controllable radiation source 12 consists of two luminescence diodes 14, 16 which emit radiation in the visible range or in the infrared range, respectively, dependent on the type used. The luminescence diodes 14, 16 are switched in series and supplied by a current I generated by a controllable current source 18.

The radiation of the luminescence diodes 14, 16 permeates the bank note 10 and is partially absorbed by it. The radiation penetrating the bank note 10 and weakened in the process meets two photo receivers 22, 24, photo diodes, for example, of the radiation receiver module 20 and is converted by it into electric signals S. These are amplified by amplifiers 26, 28 and fed to an analog multiplexer 30. The signals S of the photo receivers 22,

24 are alternating through-connected in the analog multiplexer 30 to its output and fed to an analog-digital converter 32. The digital output is connected with the input of a microcontroller 34. The microcontroller controls the analog multiplexer and starts the conversion cycle of the analog digital converter 32. The microcontroller 32 has access to a memory RAM for saving current data (signals S) and is connected via a data bus with an EPROM 38 (Erasable Programmable Read Only Memory). The EPROM 30 s rves as a program memory for the microcontroller 34 used for storing the bank

note specific data. The microcontroller 34 controls the whole process, calculates the averages and compares them, as will be described below. The microcontroller 34 controls a digital analog converter 36; its output signal serves for controlling th current I of the controllable current source 18. In addition, the microcontroller 34 is connected via a data line 44 with a computer (not shown in fig. 1) and transmits the results to the computer. The computer, in turn, transmits data for process control to the microcontroller 34.

The bank note 10 to be monitored for multiple transport is fed via a transport device (not shown) through the translumination measurement stretch formed by the controllable radiation source 12 and the radiation receiver module 20. The path traversed by the bank note 10 is detected by a position sensor 42 and transmitted by timing signals to the microcontroller 34. The controllable current source 12 and the radiation receiver module are adjustable in th manner that the range of the bank note 10 to be scanned can be selected as a scanning stretch. If the controllable radiation source 12 and the radiation receiver module 20 are adjusted in the manner that the scanning stretches run along the edges of the bank note 10, for example, a test of the sheet format or of the correct position of the bank note 10 can be made. If there is no paper sheet between the controllable radiation source 12 and the radiation receiver 20, the photo receivers 22, 24 do not receive the weakened radiation of the luminescence diodes 14, 16 which causes a significantly increased level of the signals S. Reaching this signal level can be caused by the absence or the misalignment of a bank note.

With readin of sample bank notes, the money machine can be set to a specific bank note type desired by the user. The readin process is shown in the flow diagram in fig. 2.

The set value M calculated in this manner and the corresponding sum of the difference current values ΔI characteriz the sample bank notes. With the aid of the set value M, a tolerance range with a low r limit G1 and an upper limit G2 is defined in process step 76. The av rage SM of a bank note to be monitored may be within these limits G1 and G2 so that it can be detected as belonging to this type of bank notes and as an individual bank note. In practice, the 0.8-fold of the set value M has been shown as a lower limit G1 and the 1.2-fold of the set value M. The data belonging to a specific type of bank note, the upper limit G2 and the lower limit G1, the sum of the difference current values ΔI and an identification of the bank notes, for example, are stored in process step 78 in EPROM 49 and accessed when the bank notes are monitored.

Fig. 3 shows the control function for determining the difference current values ΔI dependent on the set value M. As discussed above, the set value is supposed to level out within the range firmly preset by the values M1, M2 in as few iterative steps as possible. This range has the average value of M0. Fig. 3 shows, as an example, that a set value M′ is detected which lies clearly outside the range defined by M1, M2. A difference current value ΔI corresponding with the set value M′ can be taken from curve 50 of the control function which, in addition to the basic current value I0 and with the corresponding selection of the radiation source 12, accomplishes that the set value M measured during the next readin process will probably be within the range defined by the values M1, M2. The curve 59 of the control function must be selected in the manner that the set value M is located already during the second readin process within the range determined by the values M1, M2. It was shown in practice that the course of curve 50 of the control function is optimal when the course ascends or descends progressively, respectively, from an average value MO with increasing deviations of the set value M.

The flow diagram of fig. 4 shows the course of a monitoring process to detect a multiple transport of bank notes.

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The first process step 60 gen rates a defin d start status of the translumination measurement stretch consisting of th radiation source 12 and the radiation receiver module 20. To this end, the translumination measurement stretch is operated without feeding a bank note so that the radiation of the controllable radiation source 12 can meet the radiation receiver module 20 directly and unweakened. The controllable radiation source 12 is adjusted via the controllable current source 18 to a basic current value Io (process step 62) in the manner that the level of the signals S of the photo receivers 22, 24 is located in the upper segment of a preset working range of the analog digital converter 32, for example at 90%.

In the next process step 64, a sample bank note is advanced via the transport device in the translumination measurement stretch and scanned along the scanning stretch defined by the position of the luminescence diodes (LEDs) 14, 18 and the corresponding photo receiver 22, 24. The signals S of the photo receivers 22, 24 are read into the memory RAM of the microcontroller with time-division multiplexing. Either during the readin or after the bank note 10 has traversed the scanning stretch, the arithmetic average SM of the signals S is formed (process step 66). In order to attain a higher statistical certainty of the results during readin, the monitoring procedure is done in bifurcation 67 shown in fig. 2 with four bank notes that differ with respect to their denominations. An arithmetic total average M is calculated from the thus attained average values SM in process step 68; this total average can also be called set value M. This set value M is monitored in the next process step 70 if it is located in the preset range, formed by a lower valued M1 and a higher valued M2. These values M1, M2 are stored in the microcontroller 34 as digital values and are M1 = 100, M2 = 140 when an 8-bit microcontroller 34 is used, for example. If the set value M is outside this range, a difference current value Δl is calculated in the bifurcation 72, 74 pursuant to an empirically determined control function. This calculation will be discussed below. The basic current value lo must be changed by the difference current value Δl so that the set value M will lie between the range determined by the values M1, M2 in the next readin process with a high probability rate.

The current I used on the controllable radiation source 12 after running through the process steps 72, 74 results from the sum of the basic current value Ia and the difference current value ΔI. The readin process is repeated with feeding the bank notes according to the

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described process steps, and the set value M is compared with the values M1, M2. If the set value M is located again outside the range defined by the values M1, M2, the corresponding difference current value ΔI is calculated from the control function and added to the previously determined current I. This process is repeated until the set value M is located within the default limits M1, M2.

Before a bank note is transported into the translumination measurement stretch, the basic current value Io is calculated in the manner discussed above (process step 80). For monitoring, the microcontroller 34 accesses the bank note specific parameters consisting of the upper limit G2 and the lower limit G1 as well as the difference current ΔI that are stored in the EPROM 40. The microcontroller 34 causes the current I = Io + ΔI to be fed to the controllable radiation source 12 via the digital analog converter 36 and the controllable current source 18 (process step 84). The bank note 10 guided via a transport device to the translumination measurement stretch is scanned along the defined scanning stretches, and a sequence of scanning signals S are generated via the photo receivers 22, 24. The digital values of the scanning signals S are read into the memory RAM of the microcontroller 34 and the arithmetic average SM is calculated in the following process step 86. The average SM is then compared with the stored limit values G1, G2 (process step 88). If the average SM is within the tolerance range defined by the limit values G1, G2, the path traversed by the bank note 10 is compared with the set path in a monitoring step 90. The path traversed is determined by counting the timing signals of the position sensor 42 that are counted as long as the photo receivers 22, 24 receive weakened radiation. This type of path measurement can additionally detect the properly aligned feeding of the bank notes or their overlapping, respectively. If the limit is exceeded when the average SM is compared with the limit values G1, G2 or if the set path is exceeded, the microprocessor 34 forms an identification signal indicating the multiple transport or a faulty bank note feeding (process step 94). This signal is transmitted to the computer which suppresses the delivery or a faulty evaluation of the bank notes in the money machine. In the event of a positive monitoring result, the process step 92 is bifurcated and a signal indicating single transport of the bank note 10 is transmitted to the computer.

Because the basic current value Io is determined prior to each bank note output or in certain intervals, a change of the transmission behavior of the translumination measurement stretch is without effect. Such changes can be caused by aging of the LEDs 14, 16 or by a soiled translumination measurement stretch.

Because a defined starting status is set before readin as well as during monitoring, this monitoring process for bank notes requires practically no maintenance.

Patent Claims

1. Process for monitoring paper sheets for multiple transport by scanning the paper sheet along a preset scanning stretch and by generating a sequence of scanning signals defined by the characteristics of the paper sheets for the purpos of mitting identification signals that are compared with stored set values

charact riz d in that the scanning signals (S) are generated independent from the radiation permeability of the paper sheets (10) and that an average (SM) of the scanning signals (S) and an equivalent average (M) of the set values are used for comparison.

2. Process as defined in claim 1 **characterized** in that the intensity of radiation used for scanning is set for a specific type of paper sheets (10) in accordance with a reset value range of the average (M) of the set values.

3. Process as defined in claim 2 **characterized** in that the intensity of an electric radiation source (12) is set by controlling the current.

4. Process as defined in claim 3 **characterized** in that a basic current (Io) is detected; its radiation intensity reaches a preset scanning signal value (S) when paper sheets (10) are absent.

5. Process as defined in claim 3 **characterized** in that the current (I) for controlling the current of the radiation source (12) is determined by readin of samples.

6. Process as defined in one of the above claims **characterized** in that the current (I) corresponding with a preset control function $\Delta I = f(M)$ in at least one readin process; ΔI is the difference current value to be added to the basic current (Io) to attain the current (I).

7. Process as defined in claim 6 **characterized** in that the curve (50) of the function $\Delta I = f(M)$ for increasing absolute amounts of the difference from the average (M) of the set values and an average (M0) increases or decreases exponentially.

8. Process as defined in claim 1 **characterized** in that a identification signal for multiple transport is generated when the average

(SM) of th scanning signals lies outside an upper limit value (G2) or a lower limit (G1).

9. Process as defined in claim 8 **characterized** in that the upper limit value (G2) is the 1.2-fold and the lower limit (G1) is the 0.8-fold of the average (M) of the set values.

10. Process as defined in one of the above claims, **characterized** in that arithmetic averages are used as averages (SM), M).

11. Process as defined in one of the above claims **characterized** in that scanning is performed along several scanning stretches.

12. Process as defined in claim 11, **characterized** in that the scanning signals (S) of several scanning stretches are added.

13. Process as defined in one of the above claims, **characterized** in that the paper sheets (10) are moved along the scanning stretch for scanning.

14. Process as defined in claim 13, **characterized** in that the path traversed by the paper sheets (10) during scanning is detected and compared with a preset set value for generating an additional identification signal.

15. Arrangement for performing the process described in one of claims 1 through 14, **characterized** in that at least one translumination measurement stretch consisting of at least one controllable radiation source (12) and a radiation receiver module (20) is provided. The scanning signals generated by the radiation receiver module (20) are fed to a microcontroller (34) with at least one data memory (38,40) that forms the averages (SM, M) as well as the comparison of the averages (SM,M) for the purpose of generating an identification signal and causing an intensity control of the radiation source (12).

Fig. 1

Fig. 2

detect Io

transmit I to LEDs

$I = Io + \Delta I$

read in S

repeat 4 times

form average SM

determine ΔI

form total average M

no

$M1<M<M2$

yes

determine G1 and G2

store G1, G2, ΔI, K

Fig. 3

Fig. 4

detect Io
r ady parameters G1,G2,I
I = Io + ΔI
yes no
G1<SM<G2
set value exceeded yes
no
single transport multiple transport